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Then prove the existence of the following relation between the sides of the two pentagons:

$$(c_1^2 + c_5c_2^2 + c_6c_3^2 + c_5c_6c_4^2)(x^2 + c_5y^2 + c_6z^2 + c_5c_6v^2) = r^2 + c_5s^2 + c_6t^2 + c_5c_6u^2.$$

507. Proposed by A. A. BENNETT, University of Texas.

With the use of the compasses alone construct a circle with area five times as great as that of a given circle. (This problem is said to be due to Napoleon I.)

CALCULUS.

421. Proposed by E. H. MOORE, The University of Chicago.

Given n continuous real-valued functions $\varphi_g(x)$ $(g = 1, 2, \cdots, n)$ of the real variable x on the interval (0 1) and set exp. $\int_0^1 \varphi_g(x)\varphi_h(x) = w_{gh}$ $(g, h = 1, 2, \cdots, n)$. Prove that the determinant $|\, w_{gh} \,|$ of the matrix (w_{gh}) is always $\geqq 0$ and that it is > 0 if no two of the functions $\varphi_1, \cdots, \varphi_n$ are identically equal on (0 1).

422. Proposed by O. S. ADAMS, Coast and Geodetic Survey, Washington, D. C.

Prove that

$$\int_0^1 \int_0^1 f(xy)(1 - x)^{m-1}y^m(1 - y)^{n-1}dxdy = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m + n)} \int_0^1 f(z)(1 - z)^{m+n-1}dz,$$

$f(xy)$ being an arbitrary function of xy.

MECHANICS.

338. Proposed by J. B. REYNOLDS, Lehigh University.

A comet in a parabolic orbit crosses the earth's orbit (assumed circular) so that it remains a maximum time within it; find the comet's maximum velocity in miles per second and its time within the earth's orbit in years.

339. Proposed by C. N. SCHMALL, New York City.

A roll of cloth of very small uniform thickness a is coiled up tightly in the form of a circular cylinder of diameter d and is laid horizontally across a perfectly rough inclined plane so that its axis is parallel to the intersection of the plane with the horizontal. It is then allowed to unroll (without slipping) down the plane. Neglecting the motion of its center of gravity in the direction perpendicular to the plane, show that it will unroll entirely in the time

$$T = \frac{\pi}{4}\sqrt{\frac{6d^2}{ag \sin \phi}},$$

where ϕ is the inclination of the plane to the horizontal plane, and g the acceleration of gravity.

NUMBER THEORY.

257. Proposed by LOUIS O'SHAUGHNESSY, University of Pennsylvania.

Find a general expression for the number of positive integers from 1 to 10^t, inclusive, every one of which contains the figure 9 exactly r times $(0 \leqq r \leqq t)$.

258. Proposed by A. A. BENNETT, University of Texas.

Find a recursion formula in terms of binomial coefficients for a_n, where the a's are defined by the condition that the persymmetric determinants

$$\begin{vmatrix} a_0 & a_1 & a_2 & \cdot & \cdot \\ a_1 & a_2 & \cdot & \cdot & \cdot \\ a_2 & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & a_{n-1} \end{vmatrix} \quad \text{and} \quad \begin{vmatrix} a_1 & a_2 & a_3 & \cdot & \cdot \\ a_2 & a_3 & \cdot & \cdot & \cdot \\ a_3 & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & a_n \end{vmatrix}$$

are each equal to unity for every positive integer n.